TECHNICAL SUPPORT DOCUMENT

APPENDICES

Total Maximum Daily Load for Dissolved Cadmium, Dissolved Lead, and Dissolved Zinc in Surface Waters of the Coeur d'Alene Basin

FINAL
August 2000

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WATER QUALITY STUDIES

URSG - Nov. 1997 to Jan. 1998 (Low Flow Sampling)

Low flow sampling was conducted throughout the CDA basin principally along Canyon Creek, Nine Mile Creek, Pine Creek, and the South Fork of the Coeur d'Alene River. Approximately 120 river channel samples and 45 source discharge samples were collected. Field measurements were recorded for stream flows, source discharges (adits and seeps), and water quality parameters (pH, dissolved oxygen, and temperature). Surface water samples at these locations were analyzed for total and dissolved inorganics, including cadmium, lead, and zinc. Hardness was determined from calcium and magnesium concentrations. Descriptions were recorded for most locations to provide information on location proximity to mapped features and landmarks. Average daily flow rates at several USGS gauging stations were obtained that correspond to the date range of the sampling events. With a few exceptions, chemical concentrations, flow measurements, and hardness calculations are available for each location. A total of 12 samples did not have corresponding flow rates measured due to field conditions.

URSG - May 1998 (High Flow Sampling)

High flow sampling was conducted at many of the same locations sampled during low flow data collection. The purpose of this sampling design was to have a set of flows and chemical concentrations for both low and high flow conditions. A total of 180 river channel samples and 45 source discharge samples were collected. Approximately 50 of the channel samples were collected in the North Fork of the Coeur d'Alene River. Only one of these 50 samples corresponded to a previous location sampled during the low flow sampling phase. Otherwise, the same sampling and measurement pattern was used for this phase of work as previously described for low flow sampling. A total of 17 samples did not have flow rates to correspond to the analytical results because of high flows and other field conditions. Appendix B identifies URSG sampling locations for both the November through January and May sampling events.

MFG - Spring 1991 (High Flow Sampling)

High flow sampling was conducted at many of the same locations sampled by URSG during 1997 and 1998. Approximately 60 river channel samples and 5 source discharge samples were collected. Field measurements were recorded for stream flow and water quality parameters. Samples at these locations were analyzed for both total and dissolved inorganics, total suspended solids, and total dissolved solids. However, hardness was not determined and cannot be calculated from the analytical results reported.

MFG - Fall 1991 (Low Flow Sampling)

Low flow sampling was predominantly conducted at the same sample locations as the high flow sampling of May 1991. The sample quantities and sampling design were the same as those used for the corresponding high flow sampling phase. Similarly, hardness was not determined for this phase of work.

CH2M Hill - Oct. 1996 to Feb. 1998 (Superfund Site Groundwater & Surface Water Data)

Groundwater and surface water sampling was conducted at the Bunker Hill Superfund site surrounding Smelterville. The site covers a portion of the drainage basin of the South Fork of the Coeur d'Alene River between Kellogg and Pinehurst Narrows. One river sampling location is on Pine Creek near its confluence to the South Fork. The majority of the data is attributable to groundwater sampling across 80 monitoring well locations and eight sampling events targeting potential source areas. The remainder of the data is attributable to surface water consisting of 52 river channel samples collected primarily in locations not sampled by URSG or MFG. The surface water locations are associated with tributary streams near Government Gulch, Smelterville Flats, and Kellogg. Corresponding field measurements of surface water flow rates were recorded at only a portion of these sampling locations. Hardness was not measured nor were calcium or magnesium concentrations for calculation of hardness. Chemical analyses consisted of dissolved and total inorganics, including cadmium, lead and zinc. Supplemental descriptions were developed for all new locations to provide information on location proximity to mapped features and landmarks. Average daily flow rates at several USGS gauging stations were obtained that correspond to the date range of the sampling events.

IDEQ - Oct. 1993 to Sept. 1996 (Surface Water Quality)

Surface water sampling was conducted in the CDA basin, specifically along Canyon Creek, Nine Mile Creek, Pine Creek, and the South Fork of the Coeur d'Alene River. The sampling intervals for many locations vary considerably from biweekly to several times a year, but in general span high and low flow conditions for all locations. Approximately 940 river channel samples were collected. Field measurements of stream flow rates were recorded for approximately 85% of the river channel samples. All samples were analyzed for total and dissolved cadmium, lead and zinc. Hardness was measured for most of the samples. Average daily flow rates at several USGS gauging stations were also obtained that correspond to the date range of the sampling events.

USGS - Oct. 1998 to Sept. 1999 (Surface Water Quality)

Surface water sampling in the CDA basin at 42 sites on a monthly basis. Field measurements include flow; hardness; dissolved and total cadmium, lead, and zinc; and nutrients. Spring sampling included high flow event sampling and sampling of a discharge event along climbing and falling limb of event hydrograph.

APPENDIX D: ALLOCATION ALTERNATIVES

Allocation Alternatives

EPA has evaluated a number of allocation methods for the Coeur d'Alene (CDA) basin. The final TMDL incorporates two allocation approaches. The following are some of the approaches considered by EPA during the development of the TMDL.

Set Wasteload Allocations to Zero

By setting wasteload allocations at zero, the remainder of the loading capacity is set aside in load allocations for nonpoint sources.

Set Wasteload Allocations to Water Quality Criteria at End-of-Pipe

One way to ensure that point sources do not cause exceedances of the water quality standard for a toxic pollutant is to establish uniform wasteload allocations at the water quality criterion level.

Effluent-based Criterion

This option is a refinement of the above water quality criteria approach, applicable to the regulation of metals. The metals criteria for protection of aquatic life are based on hardness, because the toxicity of metals to aquatic life decreases as hardness increases. Thus, as a river flows downstream, its loading capacity for metals may increase due to inflows of higher hardness water, such as effluent discharges with elevated hardness. In determining whether a discharge is above the criteria, one option is to consider the effect of the effluent hardness on the loading capacity. Rather than evaluating whether a discharge exceeds the criteria for the receiving water, the effluent-based criteria (defined as the water quality criteria associated with the effluent hardness) can be calculated for each discharge to determine whether, on balance, a discharge diminishes the loading capacity of the receiving water. This method was employed for point sources along the Spokane River.

Uniform Reductions or Concentration

Another method to allocate the load among sources is to set a uniform pollutant concentration target or a uniform percent reduction for all sources. The resulting allocations will be easily developed and understood, but they may not account for variation between sources and spatial variation in loading capacity.

Available Treatment Technologies

Discharges from many sources in the CDA basin receive no wastewater treatment beyond settling ponds. Cost-effective technologies to remove metals from mining wastewaters are in widespread use in the industry, and the TMDL can consider treatment performance in setting allocations. While not specifically used to calculate allocations, EPA considered information about treatment options to evaluate the wasteload allocations in this TMDL.

For waste pile sources, Best Management Practices (BMPs) can significantly reduce metals discharges. Examples include collection/routing of runoff around metals-laden wastes, removal/backfill of a waste pile into a nearby mine or into a confined storage area, and isolation of wastes with capping material. Site-specific information is critical for developing allocations to specific sources of this kind.

This TMDL does not have the benefit of a comprehensive feasibility study for the CDA basin. Proposals for treatment of adit and impoundment wastewater can be founded upon site-specific information and understandings from relevant literature. For the waste piles and nonpoint source discharges, however, judgments on the feasibility of achieving loading reductions carry a high uncertainty because of the difficulty in quantifying source characteristics and expected reductions.

Gross Allocation and Within-Category Refinement

Because of the number of sources in the upper part of the basin, a multi-step allocation method was considered appropriate for the CDA basin. For example, a “gross allocation” was established for a general class of sources (e.g., “waste piles and nonpoint sources”). This gross allocation can then be divided into individual allocations (e.g., 3 lbs/day lead allocated to “Blue Mountain Mine Wasterock Pile 2A”) using an allocation scheme tailored to that source category.

Using a Characteristic Feature

Another option for allocation to a category of sources is to find a characteristic feature of the source that directly affects its loading. The allocations can then be developed using a “use ratio” based on this characteristic feature. For example, the loading capacity of a river for dioxin can be allocated to pulp mills based on the relative production rate (tons/day of pulp) of each mill. This achieves a reasonable and equitable allocation if sources are similar and there is a direct relationship between the pollutant discharge and production rate. Another characteristic feature that can be used to develop a use ratio is effluent flow. Dividing the available capacity by the total effluent flow, a ratio (lbs/day of pollutant per unit flow) can be multiplied by each discharge flow rate to establish individual allocations. This method was used for point sources along the Coeur d’Alene River and tributaries.

Effluent Trading for Refinement of Allocations

“Effluent Trading” is an umbrella term to describe a number of new, innovative approaches to allocate pollutant loads among sources. EPA has not issued final guidance or regulations on acceptable trading mechanisms. Nevertheless, public interest in trading is high and pilot projects (many supported by EPA) are underway throughout the country. An attractive aspect of most effluent trading approaches is the opportunity provided to dischargers and communities to participate directly in developing cost-effective solutions to a water pollution problem.

APPENDIX E: DERIVATION OF AVERAGE SOURCE FLOWS

The allocations for each discrete source were determined on the basis of actual, average flow data for the discharge. To the extent practicable, data was obtained over similar time frames. Flow data were compiled from the following sources:

1. Facilities with NPDES permitted discharges are required to submit Discharge Monitoring Reports (DMRs) which usually include monthly average and maximum flows. These data are then entered into EPA's Permit Compliance System (PCS). PCS data used for the TMDL were downloaded for the period from January 1994 to June 1998. For most locations, both average and maximum flows were reported, and an average of the average monthly flows was used for the TMDL allocations. For the sewage treatment plants at Mullan and Page and the Sunshine mine, only the maximum flows were reported. The averages of the maximum values were used to calculate the allocations for these facilities.

2. McCully, Frick and Gillman, Inc. (MFG) conducted two sampling events during 1991, intended to evaluate river contaminant levels during high flow and low flow periods.

3. URSG conducted similar, but more thorough, sampling events in November 1997 and May 1998. This study included adits and seeps which were known to discharge. Many sources were sampled during only one event. Some of the sources were not included in the initial sampling plan while others were sampled only once due to inaccessibility or inability to locate the source during one of the events.

4. EPA inspection data from March 1998 that provides flow information for some of the NPDES permitted sources.

The following sections describe source flow data compiled by target site.

Canyon Creek (Above Target Site CC288)

The discharge from the Star/Phoenix Tailings Ponds (CC816), also referred to as Star/Morning and Star-Hecla tailings, is permitted as Outfall 001 under the same NPDES permit as Star/Morning (Outfall 002 above). Flow data were taken from PCS and each of the two MFG sampling events. The Woodland Park Area Seep (CC357) is an unpermitted seep from these tailings which was sampled by MFG in 1991, but no flow was recorded. URSG reported a flow in May of 1998, which was used for the allocation.

The unpermitted discharge from the Gem #3 adit (CC355) was sampled in each of the MFG events and the May 1998 URSG sampling. Because URSG found the site dry in November 1997, a value of zero flow was averaged with the other three flows for this site. One URSG and two MFG flows were averaged for the Tamarack #7 Adit (CC372).

The Hercules Mine Portal #5 (CC353) allocation was based on the average of four flows, including one zero value because the adit was dry during the November 1997 URSG sampling event.

The Hidden Treasure adit (CC354) was sampled by URSG in November 1997 and found dry in 1998. A zero value was used for the 1998 event to determine an average for the two sampling events.

The Hecla #3 discharge at Burke (CC817) was not included in either URSG or MFG studies but was sampled during EPA inspections in 1996 and 1998. Flow was only recorded during the 1998 sampling (note also that this was a visual estimate rather than a direct measurement), so that value was used for the allocation. Other adits on Canyon Creek were each sampled once by URSG and those flows were used for the allocation.

The Tiger/Poorman adit was not included in either URSG or MFG studies but was sampled by DEQ in July 2000. The single flow estimate obtained during this sampling was used for the allocations.

Ninemile Creek (Target Site NM305)

Several unpermitted discharges occur at the Interstate Callahan mine and mill site. The waste rock discharge (NM362) was sampled during both events by URSG and MFG and the flow was averaged from the four values. The tailings seep (NM363) was sampled by URSG during both sampling events, but flow during the 1997 event was reported as insignificant so the 1998 value was used for the allocation. Two flows for the adit (NM360), obtained by URSG, were averaged to obtain the value used for the allocation.

The Tamarack 400 Level (NM364) flow was reported as “insignificant” in November 1997 and measured in May 1998, so a zero value was used for the 1997 sample to determine an average for the two sampling events. Both the Success #3 (NM359) and Success Tailings (NM374) were dry in 1997 so a zero value was averaged with the May 1998 values. The remainder of the flows on Ninemile Creek were determined from URSG measurements, and were either the average of two values, or a single sample value.

South Fork (At Wallace, Target Site SF233)

There are two NPDES permitted facilities upstream from the Wallace target site on the South Fork above the Canyon Creek confluence. The Lucky Friday Mine has three outfalls. No data are available for Outfall 002 which has not recently discharged. Data for Outfall 001 (SF607) was obtained from PCS. Flow data for Outfall 003 (SF609) was taken from DMRs for January 1996 to March 1998. Handwritten entries in a logbook, apparently belonging to the mine operator, Hecla, were used for data from December 1994 through January 1995. Additional Outfall 003 flow data were obtained from IDEQ for July, 1990 and November, 1991.

Hecla holds an NPDES permit for the Star/Morning mine. The permit authorizes discharges from Outfall 001 into Canyon Creek (discussed in next section) and from Outfall 002 into the South Fork (from a waste rock pile). The source of water from the waste rock pile includes flow from the Morning No. 6 Portal. Flow data for the waste rock pile discharge (Outfall 002) was taken from PCS monthly averages and both MFG and URSG sampling events.

The Golconda and Square Deal Adits (SF395, SF396) were sampled during both URSG sampling events and the average of the two flows was used. The remaining adits in this stretch were sampled once each during the URSG sampling events, and these flow values were used for the allocations.

PCS data was used to determine the average flow for the Mullan Wastewater Treatment Plant.

Pine Creek (Target Site PC315)

All locations on Pine Creek were sampled only by URSG and are either an average of two values where available, or the actual flowrate where only one measurement was obtained.

South Fork (at Pinehurst, Target Site SF271)

The following information applies to facilities contributing metals to the South Fork between Pinehurst and Wallace.

Sunshine Precious Metals holds NPDES permits for the Sunshine mine and Consolidated Silver mine. The Sunshine mine permit includes three NPDES permitted discharges on the South Fork or its tributary, Big Creek. Sunshine is conducting a Supplemental Environmental Project, pursuant to a consent order, that includes elimination of Outfalls 002 and 003. Therefore, only Outfall 001 is allocated a load. Flow data were obtained from PCS, with two additional values from MFG, for the tailings pond discharge, Outfall 001 (SF624). Average monthly flows were only reported for two months during the period from April 1997 to June 1998.

There has been no discharge from Sunshine’s Consolidated Silver mine in the last five years. However, Sunshine has indicated that the company is currently conducting further exploration of the mine for potential re-opening in the future. In keeping with the use of actual flow data for establishment of allocations, the allocation for Consolidated Silver is established based on the most recently reported average flowrate of .194 mgd (0.3 cfs) in the March 1993 NPDES permit application for this facility.

Flows for the sewage treatment plant at Page (SF622) were taken from PCS; however, two numbers were reported for each date in a single column. EPA determined that the lower flow number for each date is an influent value so only the higher number for each date was included in calculating the average flow. The PCS data for the Smelterville treatment plant (SF623) was unusable, due to inconsistency of the units reported, so flows were compiled from available

DMRs. The Central Treatment Plant (SF3) flow average was determined from the average monthly flows reported by EPA for the period from June 1996 through June 1998.

Silver Valley Resources holds NPDES permits for the Coeur/Galena (SF602) and Caladay (SF600) mines. The flow data for these dischargers were averaged from PCS. The Caladay average flow data included only one entry for the period from January 1994 to October 1997. The Coeur/Galena permit includes two outfalls (Lake Creek tailings pond {001} and Osburn tailings pond {002}). Because Outfall 002 commenced discharging in August 1998, it was necessary to use more recent flow information (PCS data from August 1998 to March 2000) to calculate the average flowrate. The average of the average monthly flows reported over this period for Outfall 002 (0.775 cfs) was used in the allocation.

The remaining allocation flows for adits in this reach were taken from URSG sample events. Where the flow was successfully measured during both events, the average value was used. A “zero” value was used in calculating average flow for Coeur d’Alene Mineral Point (SF384) since it was reported dry during one sampling event. Where only one flow was recorded, that value was used for the allocation.

APPENDIX F : METALS FLUXES FROM COEUR D'ALENE LAKE SEDIMENTS

The long-term risk of metal release from lakebed sediments was a major reason that a detailed limnological study of Coeur d'Alene Lake was conducted in the early 1990's, the results of which are described in Woods and Beckwith (1996). The justification for the study was based on the following two key issues gleaned from previous studies of the lake: 1) the lake exhibited classic symptoms of eutrophication; and 2) the lakebed sediments contained highly enriched concentrations of metals such as arsenic, cadmium, lead, and zinc. The research question posed for the study was therefore, "Has Coeur d'Alene Lake advanced far enough in the eutrophication process to have a substantial risk to develop an anoxic hypolimnion, which would increase the potential for release of nutrients and metals from the lakebed sediments into the overlying water column?"

The limnological study addressed the eutrophication issue with water-quality data collected in the lake and its watershed, as well as empirical modeling. The trophic state of the majority of the lake was determined to be oligotrophic on the basis of concentrations of nitrogen, phosphorus, and chlorophyll-*a*. Despite its oligotrophy, the deeper areas of the lake had a substantial hypolimnetic dissolved-oxygen deficit, which is symptomatic of eutrophication. A nutrient load/lake response model was used to determine the response of the hypolimnetic dissolved-oxygen deficit to incremental increases or decreases in nutrient loads to the lake. Modeling results indicated the lake has a large assimilative capacity for nutrients before anoxic conditions were likely to develop in the hypolimnion. Limnological monitoring conducted between 1995 and 1999 indicate that oligotrophic conditions have continued and that the hypolimnetic dissolved-oxygen deficit has lessened somewhat (written communication, G. Harvey, Idaho Division of Environmental Quality, January 2000).

The limnological study also addressed the lakebed metals issue via collection and analysis of about 150 surficial samples of the lakebed sediments followed by collection of 12 cores of lakebed sediments (Horowitz and others, 1993, 1995). The goal of the analytical work was to determine concentration, partitioning, and potential environmental availability of selected metals. About 85 percent of the lakebed's surface area was found to be highly elevated in antimony, arsenic, cadmium, copper, lead, mercury, silver, and zinc. The depth of elevated sediments ranged from 17 to 119 centimeters. The chemical distribution of metals throughout the lake clearly indicated that their source was the Coeur d'Alene River. Most of the metals in surficial and core samples were associated with ferric oxides and thus would be subject to redissolution under the reducing conditions that can occur within an anoxic hypolimnion. Previously, the metals in the lakebed sediments were thought to be associated with sulfides and, under reducing conditions, would remain immobile.

There is little doubt that the lakebed sediments in Coeur d'Alene Lake have elevated levels of metals and that the source of those metals is the long-term mining and ore-processing activities within the Coeur d'Alene River Basin. The presence or absence of an oxidized microzone in the lakebed sediments and its effect on metal flux has been critically discussed in the expert reports from Falter (1999), Maest (1999), and Pederson/Carmack (1999). Observations by Horowitz and others (1993) during collection of surficial samples of lakebed sediments from Coeur d'Alene Lake noted that many of the samples had a thin (few millimeters) veneer of fine-grained reddish material overlying an oxidized layer between 1 and 5 centimeters thick. Maest (1999) reviewed core-derived, pore-fluid concentration data for iron, manganese, and sulfate, as reported by Balistrieri (1998), and concluded the profiles showed classic patterns for a transition from oxygenated conditions near the sediment-water interface through suboxic and anoxic conditions deeper in the sediment profile. The presence of an oxidized microzone highly enriched in metals, an oxic hypolimnion, and the metal-rich veneer at the lakebed surface all indicate remobilization of metals within the upper sediment column accompanied by some unquantified degree of sequestration at the sediment- water interface.

The first estimates of the flux of metals from the lakebed sediments of Coeur d'Alene Lake were made by Balistrieri (1998) using porewater data collected in 1992 as part of the limnological study. On the basis of porewater extracted from sectioned and centrifuged cores and diffusion-controlled samplers. Balistrieri concluded the lakebed sediments were a source of dissolved zinc, copper, manganese, and, possibly, lead. However, Balistrieri noted uncertainties in the original data and recommended additional research to verify the direction and magnitude of fluxes.

Ongoing litigation (U.S. v. ASARCO) over the link between mining industry practices and the presence of highly elevated levels of metals in Coeur d'Alene Lake have brought close scrutiny of the limnological study in expert reports from the plaintiffs (Falter, 1999; Maest, 1999) and defendents (Pederson and Carmack, 1999). A central issue is whether the metals in the lakebed sediments are associated with ferric oxides or sulfides because that association bears directly on the direction and magnitude of potential benthic fluxes of metals in the presence of an anoxic hypolimnion. A litigated resolution of the metal-association issue may be in the future; however, current information can be synthesized to answer the question about the long-term risk of metal release from lakebed sediments.

Water-quality data collected in the 1990's indicate that the lake may receive a flux of metals from its lakebed sediments. The early-1990's limnological study revealed a definite elevation of whole-water recoverable concentrations of lead and zinc in the lower hypolimnion in comparison to epilimnetic concentrations. Dissolved metals data collected in the summer of 1999 indicated that cadmium, lead, and zinc concentrations in the lower hypolimnion were from between 1.5 and 3 times higher than those measured in the epilimnion (written communication, P. Woods, U.S. Geological Survey, January 2000). Three processes, separately or in combination, could explain these concentration differences. In the first, the inflow plume of the Coeur d'Alene River and its associated metal load enters the lake as an interflow or underflow current into the lake's hypolimnion on a seasonal basis (e.g., underflow tends to occur from October through December because the river cools faster than the lake). Secondly, metals taken up by phytoplanktonic production in the epilimnion may settle into the hypolimnion upon the demise of those phytoplankton. The third process is remobilization of metals within the lakebed sediments and subsequent release into the overlying hypolimnion.

In the near future (Summer 2000), an improvement in the understanding of the role of remobilization and benthic flux will be available from a study conducted by the U.S. Geological Survey. This study employed two independent research methods to measure benthic flux in Coeur d'Alene Lake during August 1999. A benthic flux chamber (also called a "lander") was placed on the lakebed to measure numerous variables associated with the geochemical interaction of the lakebed sediments and overlying water column. Concurrently, a series of lakebed sediment cores and overlying hypolimnetic water samples were collected with specialized sampling equipment. The cores were incubated using dissolved-oxygen concentrations from saturated to anoxic in order to measure the metal flux between lakebed sediments and the overlying water column over a gradient of redox conditions.

Preliminary results from the August 1999 study indicate that the potential magnitude of metals fluxes into and out of lake sediments is significant in relation to the metals loadings from the Couer d'Alene River (Kuwabara, personal communication). The lander and core sample results both indicate that dissolved lead fluxes are occurring from the sediments to the overlying water column. The two methods, however, provided conflicting results with respect to the direction of dissolved cadmium and zinc fluxes (lander indicates a positive flux, cores indicate a negative flux). Analyses of water overlying the cores under anoxic conditions indicated smaller fluxes of lead and a negative flux of both cadmium and zinc. This suggests that large fluxes would not occur if the lake became anoxic at depth over the long term due to eutrophication. Questions remain about the representativeness of the core sampling techniques, seasonal variability of fluxes and potential changes to fluxes resulting from future cleanup actions along the Coeur d'Alene River.

A review of water quality data collected by USGS upstream and downstream of the lake indicates that, despite the positive fluxes from the sediments, the lake as a whole acts as a sink for dissolved metals inputs from the Coeur d'Alene River. Dissolved metals loads exiting the lake for lead at the Post Falls dam are significantly lower than the loadings entering the lake from the Coeur d'Alene River; cadmium and zinc loads appear lower at the Post Falls dam as well, but to a lesser degree (Woods, personal communication). This data suggests that fluxes from the sediments measured in the lander study may be smaller in magnitude than dissolved metals reductions due to planktonic uptake, chemical interactions, or other processes occurring in the lake.

In conclusion, available data indicate that the chemical, physical, and biological processes affecting dissolved metals concentrations in the lake currently result in a net reduction in the metals loads introduced by the Coeur d'Alene River. EPA also believes the long-term risk for a substantial release of metals from lakebed sediments is low because (1) Coeur d'Alene Lake's large assimilative capacity for nutrients makes it very unlikely that an anoxic hypolimnion will develop, and (2) core samples did not release larger metals loads under anoxic conditions (in fact, cadmium and zinc fluxes were negative in the tests). The lake's susceptibility to eutrophication, a prerequisite for an anoxic hypolimnion, can be managed if nutrient loads to the lake are not allowed to increase appreciably.

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APPENDIX G : FATE AND TRANSPORT OF SURFACE WATER METALS

One of the fundamental assessment questions for the Coeur d'Alene River Basin TMDL is the following: Are there chemical, physical, and/or biological mechanisms occuring in the river that consistently remove dissolved metals from the water column? EPA notes that the fate of particulate metals (metals attached to particles) is not the subject of this TMDL, which is focused on achieving Idaho water quality standards for dissolved metals in the water column.

While biological uptake processes may be important in the lake environment (see discussion of potential planktonic uptake in Appendix F), biological processes are not expected to significantly alter or remove dissolved metals in the upstream riverine environment.

Conversely, chemical/physical processes such as adsorption and precipitation can potentially remove dissolved metals from the water column. These processes involve complex and dynamic interactions between metal species in the presence of other waterbody consituents. Since the water quality criteria are not established for specific metal complexes (e.g., cadmium sulfate) but rather for the sum of metal ions (e.g., dissolved cadmium), which can be directly measured, it is not important to evaluate physical/chemical processes that may occur in the water column or sediments for the TMDL. However, it is important to determine the amount of total metal and dissolved metal to calculate translators. Fortunately, for the Coeur d'Alene River and tributaries, there is a sufficient body of paired river samples (dissolved vs. particulate metal) to directly calculate the translators.

EPA has evaluated the ratio of particulate (total recoverable) metal to dissolved metal in the Coeur d'Alene River and tributaries. This ratio is also called a "translator" in the NPDES program. Cadmium and zinc in the river are almost entirely in the dissolved form at all of the target sites (i.e., the translator is approximately 1). For lead, the particulate fraction is a significant portion of the total lead concentration at a number of target sites. This is consistent with preliminary analyses from the RI/FS indicating that lead can be expected to adsorb and/or co-precipitate with iron in basin waters. The particulate lead fraction increases in the downstream direction from the South Fork headwaters to the Spokane River.

EPA also reviewed the available data for the South Fork Pinehurst station to determine whether the total-to-dissolved ratio varies with respect to river flow. Over the range of flow tiers established in the TMDL (68 cfs to 1290 cfs), there was no discernible relationship between river flow and the total-to-dissolved ratios for cadmium, lead, and zinc.

Recent data collected by the USGS indicates that during peak runoff events, the total-to-dissolved ratio for lead increases significantly in basin waters. The flows at which this phenomenon occurs are higher than the top flow tier in the TMDL (greater than 1290 cfs). Since the total-to-dissolved ratio at the top flow tier is more stringent than the actual ratio during peak runoff events, the lead translators in the TMDL provide a margin of safety during peak runoff events.

In conclusion, the available paired samples indicate that dissolved cadmium and zinc are not appreciably removed from the water column in Coeur d'Alene Basin waters, while dissolved lead is removed to some extent to the particulate form between the headwaters and lower basin. This transformation of dissolved lead toward particulate lead is captured in the translator applied to the wasteload allocations in the TMDL.

APPENDIX H : TMDL CALCULATION SPREADSHEETS

Cadmium Spreadsheet

Lead Spreadsheet

Zinc Spreadsheet

APPENDIX I : HARDNESS DATA

APPENDIX J : TRANSLATOR DATA

APPENDIX K : TMDL FEASIBILITY AT THE BUNKER HILL CTP

Introduction

This appendix summarizes the approach taken, and the results to date, for developing compliance strategies for the Total Maximum Daily Load (TMDL) allocation assigned to the Central Treatment Plant (CTP), which treats the drainage from the Bunker Hill Mine in Kellogg, Idaho.

Approach

The following summarizes the TMDL compliance approach to date:

- A hydrologic comparison of recorded flows from the Kellogg Tunnel (KT) of the Bunker Hill Mine and at the Pinehurst gauge on the South Fork of the Coeur d'Alene river was conducted, because the Pinehurst gauge will be used to measure TMDL compliance for the CTP. The allowable monthly average discharge of cadmium, lead, and zinc is dependent on river flow rate.

- Sampling of the current CTP effluent for dissolved metals was initiated. This was done to determine the capability of the existing lime high density sludge treatment process to remove dissolved cadmium, lead, and zinc. Previously only total cadmium, lead, and zinc of the effluent were monitored.

- Additional treatment technologies (sulfide precipitation, iron co-precipitation, and ion exchange) were reviewed and tested in the laboratory for their ability to produce treated water of sufficient quality for TMDL compliance. Emphasis was placed on technologies that could complement the existing lime high density sludge process.

- Source control measures, which could reduce the recharge of surface and groundwater to the mine, were identified with the goal of reducing the amount of flow and pollutant loads requiring treatment.

- A computer model was developed to evaluate compliance with the TMDL assuming different mine water flow rates, treatment plant sizes, effluent concentrations, water management and storage facilities, and river flows.

Results to Date

- The hydrologic evaluation found little correlation between historic mine and river flows on a daily basis. This is likely due in part to the hydrologic differences between the South Fork's large east-west trending watershed and the north-aspect watersheds that overlay the mine, and in part to historic in-mine water management activities. This lack of a correlation necessitated selection of representative annual data sets of KT and river flows for computer modeling.

- Several source control measures have been identified which have potential to reduce both the peak and base flow rates from the mine. These measures may allow for operation of smaller scale treatment equipment.

- The computer model is being used to evaluate sizes of treatment equipment needed depending on the amount of source control that is achieved. The model is also used to evaluate use of pre-treatment storage of mine water for either peak flow reduction or contingency storage in the event of treatment plant shutdown, mine flood, or other unforeseen event.

- The computer model results show that as long as the CTP effluent concentrations of cadmium, lead, and zinc are below certain threshold values, that the TMDL load allocations do not restrict discharges below the design flow of the treatment plant. This reduces the need for large volumes of pre-treatment storage for TMDL compliance.
  Dissolved metals sampling of the CTP effluent indicates that the existing treatment process may be sufficient to achieve compliance with the TMDL with addition of filtration. Average CTP effluent concentrations of dissolved metals collected during treatability sampling are as follows:

Cadmium:	0.50 mg/L
Lead:	0.1 mg/L
Zinc:	18 mg/L

- Laboratory treatability testing has evaluated addition of sulfide precipitation, iron co-precipitation, and ion exchange to the existing lime high density sludge treatment process to further reduce concentrations of dissolved cadmium, lead, and zinc. The addition of soluble sulfide into the lime neutralization process was selected for follow-on testing during the summer of 2000 because it performed as good or better than the other technologies, plus it was considered to be the most cost effective. Dissolved metals were lowered to the following concentrations using sulfide addition during laboratory testing:

  Cadmium: 0.07mg/L
  Lead: < 0.32 mg/L
  Zinc: 15 mg/L

- Filtration of the CTP effluent using either media or micro filters will be needed to reduce suspended metal in the CTP effluent. Both media and micro filtration will be tested during the summer of 2000.

APPENDIX L : RIVER FLOW REGRESSIONS